AGE DETERMINATION AND GROWTH OF *DISSOSTICHUS ELEGINOIDES* SMITT, 1898 FROM KERGUELEN AND CROZET ISLANDS

by

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ABSTRACT. – Age determination was made by studying scales with polarised light. Studied specimens were aged from less than one year to twenty-one years. The method used is described in detail.

RÉSUMÉ. – La détermination de l'âge a été faite à l'aide des écailles observées en lumière polarisée. Les spécimens étudiés sont âgés de moins d'un an à vingt-et-un ans. La méthode utilisée est décrite en détail : l'étude rétrospective de la croissance montre en particulier que cette méthode est très utile lorsqu'on dispose d'un nombre relativement réduit d'individus. Les résultats sont comparés, d'une part à ceux obtenus sur le même stock à partir de la détermination de l'âge de nombreux individus, d'autre part à ceux obtenus par d'autres auteurs sur les stocks de la région magellanique et de l'Antarctique de l'Ouest. Les *Dissostichus eleginoides* des îles Kerguelen et Crozet ont une croissance plus lente et plus faible et ils atteignent la maturité sexuelle à une taille plus petite.

INTRODUCTION

During the course of the oceanographical cruises of the N.O. « Marion-Dufresne » (1974 to 1976 : MD03, MD04 and MD08) numerous specimens of *Dissostichus eleginoides* were caught. The wide range of sizes (69 to 845 mm) allowed a study of the growth of this species to be made, 69 specimens originating either from the Kerguelen Islands or from the Crozet Islands were examined during the course of this study. The otoliths and samples of scales were removed from each fish and the standard length measured systematically whilst on board the ship. The weights were either noted on board when the fish were fresh or else recorded later following preservation. A series of tests showed that the weight of the fresh fish diminished by about 6 % after two years in preservative. In order to compare all of the measurements, therefore, the fresh weight have been reduced by this amount.

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TECHNIQUES UTILISED

Collection of scales

Scales were removed from the flank, or from the base of the anal fin, or else from behind the pectoral fin if the fish had been damaged. They were stored and dried in labelled envelopes. Those scales which had little detail in the central area (replacement scales) were discarded. The best scales were those that had been removed from along the base of the anal fin. The general form of the scales is oval, the posterior field being clearly indented in the older specimens and the edge of the posterior field adorned with fine short spines.

The scales removed from specimens preserved in alcohol were easier to examine than those removed from fresh specimens, however, in the course of drying, the former have a tendency to fold or roll up although when placed in water they unfold completely within a few seconds.

Examination of scales

Scales were examined in water under a microscope by natural and polarised light.

In natural light the annual checks, marked by a thickening of the scale at the level at which the circuli are slightly more closely spaced, are first distinguished (Fig. 1). These zones correspond to the slow growing periods. Secondly, the fast growing zones, characterised by a thinning of the scale in the zone where the circuli are widely spaced, are identified.

The contrast between the different zones is generally most marked when the scales are examined under polarised light (Fig. 2), and, towards the centre of the scale, this form of illumination makes splits (false checks) more easily recognisable. Using polarised light some problems arise in recognising essential details where the circuli from one zone merge with those of another (Fig. 3).

As an experiment, some scales were mounted on slides in a synthetic resin (Eukitt) but this rendered too many features transparent to be of use.

Observation on the otoliths

Initially the study of otoliths proved difficult since neither burning, nor sectioning made the growth rings clearly visible : in addition their large size rendered the polishing technique long and arduous. However, during the Workshop on age determination of antarctic fish (Cambridge, August 1979) several tests were made with a burning technique on otoliths from specimens whose scales we had already studied. Several participants at the workshop tried to read these otoliths without knowing our results of age determination based on the scales. The agreement between the results was particularly good and two examples are listed below :

	Estimated age	
Example	A	B
Otolith (Workshop)	20+	5+
Scales (Our results)	21	5+

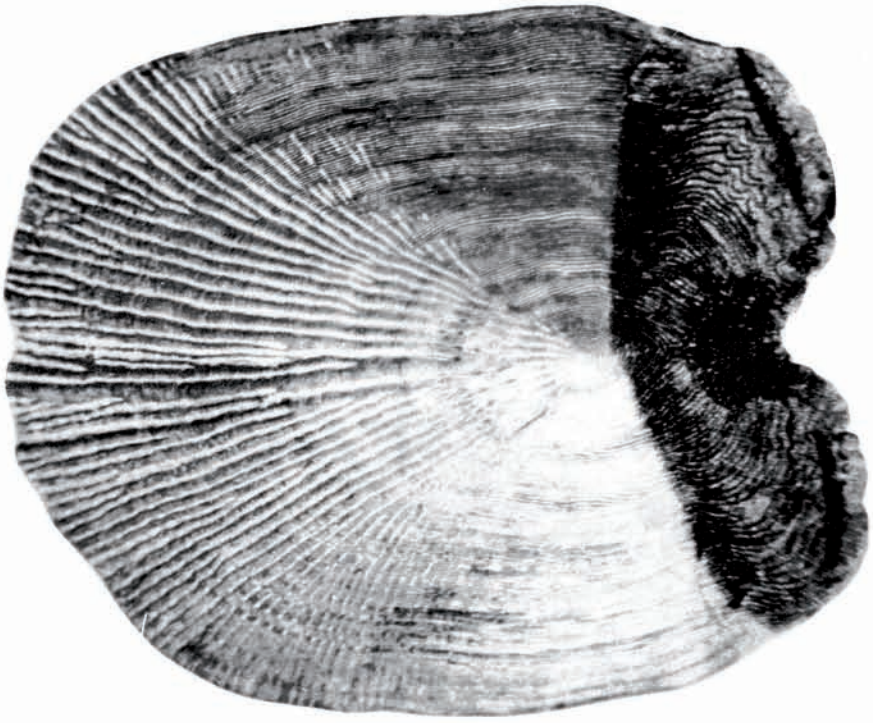

Fig. 1. – *Dissostichus eleginoides* 21 years old. Scale examined under normal light.

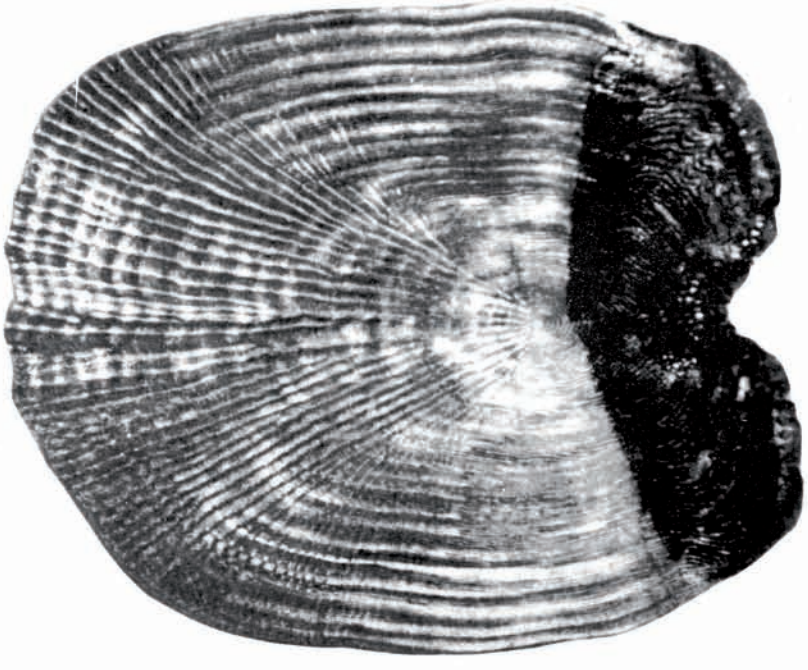

Fig. 2. – *Dissostichus eleginoides* 21 years old. Scale examined under polarised light.

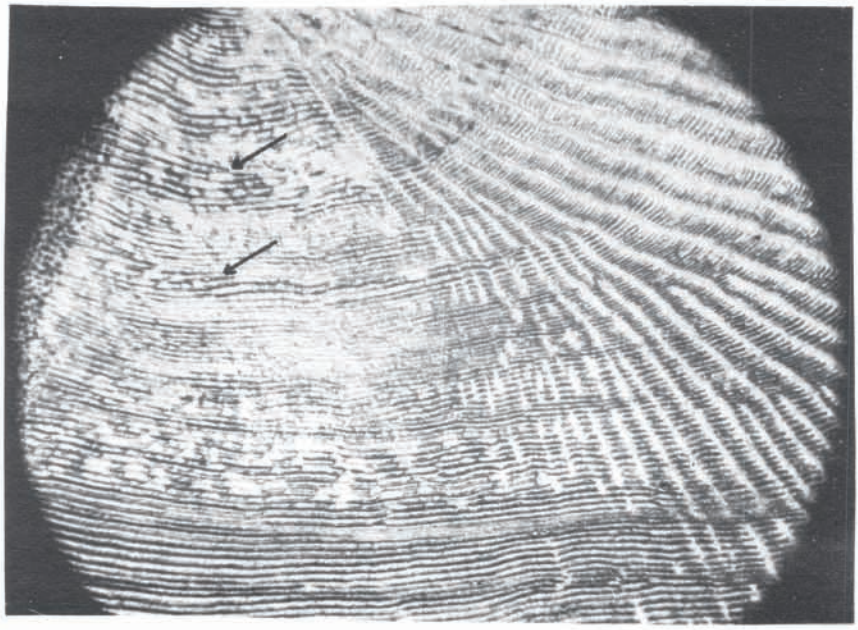

Fig. 3. – Enlarged view of a scale (normal light) showing details of circuli from one annulus merging with those of another.

The technique of mounting the otoliths in black polyester resin and cutting thin slices (1), has also been used and the results are in good agreement with the other techniques.

Interpretation of the annuli on the burned otoliths is not difficult : large otoliths have an easily recognisable nucleus surrounded by 7 rather large annuli, proceeding outwards these are followed by a succession of narrower regular annuli, the spawning zones. The spawning zones thus appear at an age of about seven or eight years which corresponds to a standard length of about 380 mm for our fish from Kerguelen. At South Georgia fish spawn first when 55 - 60 cm total length (Kock 1976).

Method of age estimation

The fish were placed into classes depending on the number of annuli that were observed in their scales. A fish of class I would possess 1 visible annulus and a fish of class n possesses n annuli.

From our observations on the gonads we consider that spawning occurs during the month of May since two large specimens (length 800 and 845 mm), captured on April 20th and 21st 1976 had gonads containing ripe ovules. The first winter (slow growing period) of the young fish's life does not involve the formation of a recognisable annual check on the scales although there is a characteristically

(1) We are grateful to B C Bedford of Fisheries Laboratory Lowestoft for his help in using this technique.

slight thinning of the centre. Hatching may occur during or just after this first winter. The first annual check we have observed (class I) therefore corresponds to an age of 1 year and 10 or 11 months, taking into account the dates of capture (which in all cases were March or April) (Fig. 4). Likewise a fish belonging to class n is aged n years + 10/11 months, after spawning. In fact the true age (after spawning) is less since we do not know the interval between spawning and hatching. This may be only a few weeks or up to several months.

Whatever the precise date at which scales start to be formed, the first annual check observed from the centrum (= focus) corresponds to the second winter after spawning.

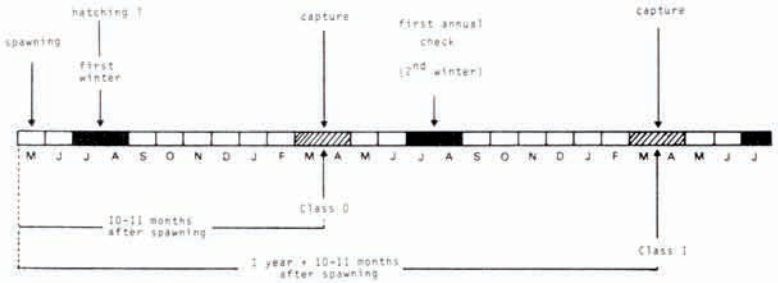

Fig. 4. – Age estimation by mean of the observation of annuli in function of the dates of spawning and capture.

INTERPRETATION OF THE RESULTS

Experimental curve of growth in length

Table I gives the estimated size (SL) and weight (W) of the fish in each class. The length at age results are plotted out in Fig. 5 and a linear regression fitted to them by the method of least squares.

$SL = 124.4 + 36.6\,t$ $\quad (r = 0.99)$ . . . . . Equation 1

SL = Standard length in mm

t = Age class (the class corresponds to the age less 10 - 11 months after spawning).

Scalimetry and theoretical growth curve

A scalimetry study was carried out on 14 scales taken from fish whose standard lengths ranged from 80 to 845 mm. The distances l_n between the centre of the scales and the beginning of each of the 'n' annual checks were measured using a drawing apparatus. All the measurements were made along the boundary between the anterior field and one of the lateral fields. Along the same axis the distance D from the centre to the edge of the scale was also measured.

The formula of Lea (1910) (retrospective study of growth)

$$\frac{D}{SL} = \frac{l_n}{SL_n}$$

SL = Standard length of the fish

SL_n = Standard length corresponding to the beginning of the annual check.

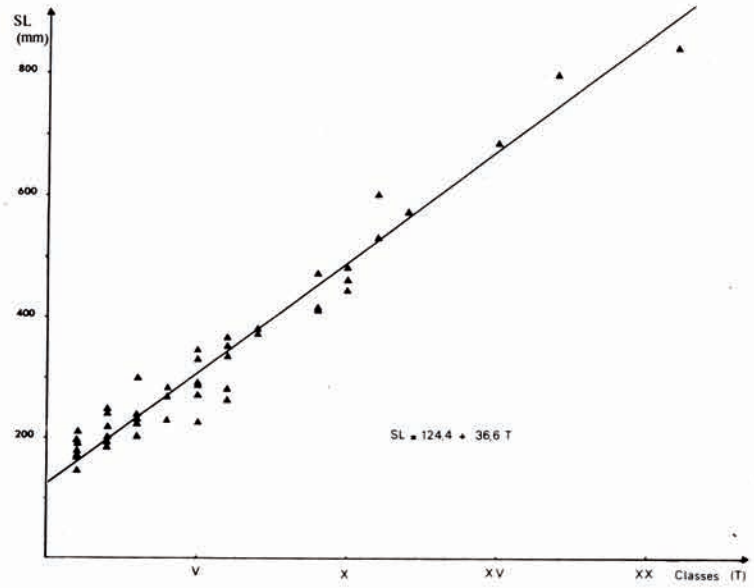

Fig. 5. – Experimental curve of growth in length.

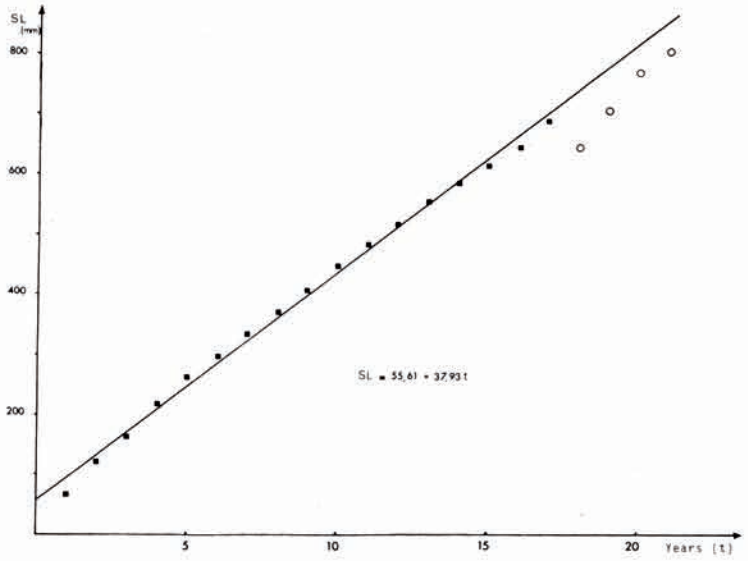

Fig. 6. – Curve of growth in length obtained by scalimetry : the squares correspond to the means between several values, the circles represent a single value from a scale taken on the oldest example (see Table II)

For each scale it was thus possible to calculate the SL_n corresponding to each annual check. The measurements were made to the beginning of each annual check, and the lengths thus derived correspond to ages of 1, 2, 3, ... years (cf. Fig. 4). For each age a mean theoretical standard length was calculated. The results are set out in Table II and the derived curve of growth in length obtained by scalimetry is shown in Fig. 6. A linear regression with the following constants has been fitted to the results :

$SL = 55.61 + 37.93\ t'$ $\quad (r = 1)$ . . . . . Equation 2

The slope of the experimental line (Equation 1) is very close to that obtained by scalimetry, however, the values of SL obtained by the second are systematically lower by 15 to 20 mm.

The scalimetric method, even though the precision is less, does have the advantage of being more rapid since it requires observations from fewer scales which have preferably come from larger fish.

Growth in weight

A curve of growth in weight (Fig. 7) has been constructed from the information in Table I. In addition, a transformation curve linking standard length and weight is given in Fig. 8 (this is plotted on a logarithmic scale). The corresponding regression equations are :

$\log W = 3.58 \log SL - 14.76 \quad (r = 0.99)$
or $W = 3.9 \times 10^{-7}\ SL^{3.58}$

CONCLUSION

During the Workshop on age determination of antarctic fish we concluded that since there was good agreement between the observation made with scales and otoliths the age determinations based on scale reading are valid. During the discussions, we noticed some important differences from the results obtained by Kock (1976) concerning the size of first sexual maturity of *Dissostichus eleginoides* from the Magellanic region and South Georgia in comparison to those from Crozet and Kerguelen Islands. We conclude that the two stocks are separate and have several different biological characteristics : namely that the maximum total length observed (130 cm) and size at first sexual maturity (SL : 38 cm) are smaller in specimens from Crozet and Kerguelen than in those from South Georgia (maximum total length observed : 170 cm and maturity at 55- 60 cm) or from the Patagonian region (maximum length recorded by Zacharov and Frolkina (1976) : 186 cm for a fish aged 22 years). Furthermore Meissner and Kratky (1978) recorded maximum sizes of 134 cm for the fish caught by Soviet ships fishing in the Kerguelen area - these results are in accord with our observations.

Furthermore it is obvious that in the Kerguelen stock of *Dissostichus eleginoides* the growth is slower than in the South-west Atlantic stock. For example a fish aged 6 years measures about 63 cm (total length) in the SW Atlantic (Zacharov and Frolkina, 1976) and about 30 cm (standard length) in the Kerguelen area (Fig. 6).

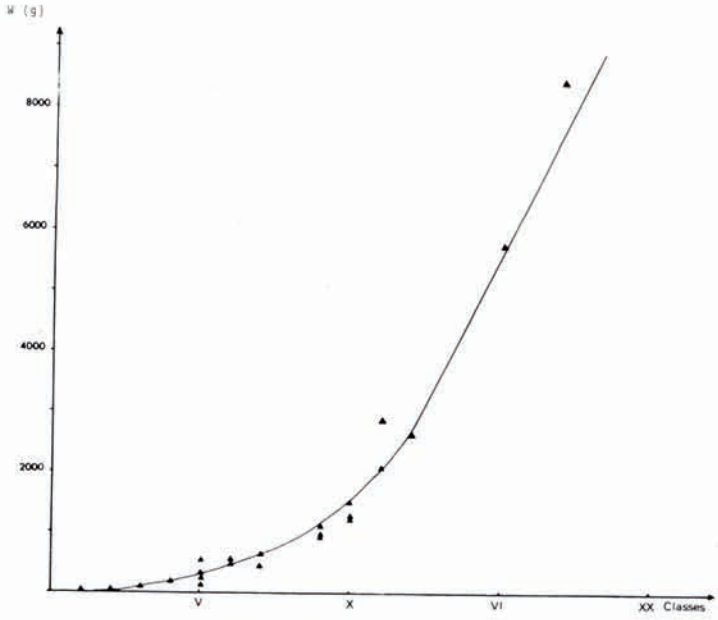

Fig. 7. – Curve of growth in weight (W).

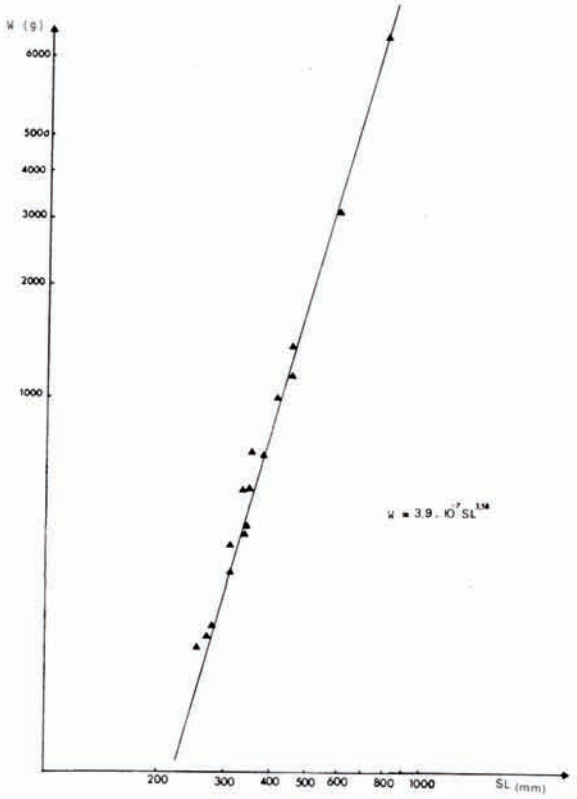

Fig. 8. – Transformation curve between standard length and weight (logarithmic coordinates).

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TABLE I : Standard lengths (SL) and weights (W) for each class in *Dissostichus elegenoides*. Values of W for specimens preserved in alcohol, Value of SL for fresh specimens)

CLASS	SL (mm) range	SL (mm) mean	number of specimens measured	W (g) range	W (g) mean	number of specimens weighed
I	148-210	183,30	10	31-69	51	8
II	185,5-247	200,75	12	51-71	62	5
III	205-303	235,25	8	98-115	107	3
IV	232-283	261,67	3	89-214	151,5	2
V	227-345	292,17	6	101-575	291	5
VI	280-366	320,4	6	430-564	496,5	4
VII	376-380	378,0	2	658-710	684	2
VIII	–	–	–	–	–	–
IX	413-472	433,33	3	940-1150	1017	3
X	445-485	465,0	3	1551-1269	1363	3
XI	535-605	570	2	2115-2961	2538	2
XII	–	575	2	–	2679	1
XIII	–	–	–	–	–	–
XIV	–	–	–	–	–	–
XV	–	690	1	–	5781	1
XVI	–	–	–	–	–	–
XVII	–	800	1	–	8460	1
XVIII	–	–	–	–	–	–
XIX	–	–	–	–	–	–
XX	–	–	–	–	–	–
XXI	–	845	1	–	10199	1

TABLE II. – Scalimetric study of *Dissostichus eleginoides*

SL : Standard length of the specimens

$l_{1 \ldots 21}$: Distance between the centrum of scales and the beginning of annual checks between ages 1 and 21

D : distance between the centrum and the edge of the scale

SL_n : Standard length corresponding to the beginning of the n^{th} annual check

MD08 Cruise Station nº	St. 62 CP 257	St. 62 CP 257	St. 62 CP 257	St. 62 CP 257	St. 13 CP 85	St. 68 CP 275	St. 13 CP 85	St. 78 CP 319	St. 09 CL 63	St. 73 CP 295	St. 09 CL 63	St. 73 CP 295	St. 75 CL 306	mean SL_n
SL (mm)	172	240	303	283	345	353	380	413	485	535	690	800	845	
D	18	34	31	34	44	40	44	60	82	103	117	115	118	
Classe	I	II	III	IV	V	VI	VII	IX	X	XI	XV	XVII	XXI	
l_1	7	9	8	6	12	7	7	8	8	12	13	7	8	
SL_1	66,9	63,5	78,2	49,9	94,1	61,8	60,4	55,1	47,3	62,3	76,7	48,7	57,3	63,25
l_2		26	14	14	19	12	12	14	21	20	20	14	12	
SL_2		183,5	136,8	116,5	148,9	105,9	103,6	96,4	124,2	103,9	117,9	97,4	85,9	118,4
l_3			23	19	25	16	19	20	34	29	28	21	15	
SL_3			224,8	158,1	196,0	141,2	164,1	137,7	201,1	150,6	165,1	146,1	107,4	162,9
l_4				27	32	24	25	30	44	42	34	30	22	
SL_4				224,7	250,9	211,8	215,9	206,5	260,2	218,2	200,5	208,7	157,5	215,5
l_5					39	29	30	35	51	53	40	40	25	
SL_5					305,8	255,9	259,1	240,9	301,6	275,3	235,9	278,3	179,0	259,1
l_6						34	34	40	57	63	47	46	29	
SL_6						300,0	293,6	275,3	337,1	327,2	277,2	320,0	207,7	292,3
l_7							38	45	64	74	54	52	33	
SL_7							328,2	309,7	378,5	384,4	318,5	361,7	236,3	331,0
l_8								49	68	81	64	56	40	
SL_8								337,3	402,2	420,7	377,4	389,6	286,4	368,9
l_9								53	73	87	73	62	45	
SL_9								364,8	431,8	451,9	430,5	431,3	322,3	405,4
l_{10}									76	92	80	68	50	
SL_{10}									449,5	477,9	471,8	473,0	358,0	446,0
l_{11}										98	87	76	54	
SL_{11}										509,0	513,1	528,7	386,7	484,4
l_{12}											95	82	58	
SL_{12}											560,2	570,4	415,1	515,3
l_{13}											100	90	63	
SL_{13}											589,7	626,1	451,1	555,6
l_{14}											104	95	66	
SL_{14}											613,3	660,9	472,6	582,3
l_{15}											110	98	71	
SL_{15}											648,7	681,7	508,4	612,9
l_{16}												103	80	
SL_{16}												716,5	572,9	644,7
l_{17}												110	86	
SL_{17}												765,2	615,8	690,5
l_{18}													90	
SL_{18}													644,5	–
l_{19}													99	
SL_{19}													708,9	–
l_{20}													108	
SL_{20}													773,4	–
l_{21}													112	
SL_{21}													802	–